with such force that it causes the valves in the jugular and subclavian veins to close with a snap, which he was able to hear over these veins as a clear, sharp sound preceding the first sound.

Regarding the diagnosis, Shattuck says: "Whether a presystolic souffle can be heard or not, tricuspid stenosis can be pretty safely diagnosticated if the patient is a female with rheumatic history, has mitral stenosis, perhaps also, aortic disease, and presents the evidences of prolonged or recurrent venous stasis of greater or less degree."

The fact that, including the cases here reported, the clinical diagnosis has been made in only 13 out of the 195 cases reported, indicates that recognition of the lesion is not easy. It is nearly always complicated by the physical signs of mitral and aortic disease and this helps to obscure the picture. Another factor must be taken into consideration, and that is, that many of the hospital cases are admitted in a moribund condition. This occurred in two instances in the present series and prevented careful study.

THE OPERABILITY OF INTRAMEDULLARY TUMORS OF THE SPINAL CORD.

A REPORT OF TWO OPERATIONS, WITH REMARKS UPON THE EXTRUSION OF INTRASPINAL TUMORS.[1]

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A study of the literature on intramedullary tumors of the spinal cord will show that almost all authors consider growths within the substance of the cord as inoperable. A few writers (Rothman, etc.) have suggested that such tumors might be operated upon, but Oppenheim, Bruns, and others only mention this possibility.

Intramedullary tumors are not by any means as rare as ordinarily they are believed to be. Thus Allen Starr,[2] quoting from Schlesinger, states that among 302 tumors of the cord, 125 were within the cord substance. These included sarcoma, tubercular tumors, gumma, glioma, lipoma, cysticercus, neuroma, cholesteatoma, myxoma, teratoma, adenoma (Benda), endothelioma, etc. Many of these intramedullary growths infiltrate the cord substance and increase in size by extending upward and downward, but some enlarge in their transverse diameter, are encapsulated, and of small size. Gowers[3] states that "these tumors in some cases blend with the substance of the cord, but in other instances they are bounded by an area of softening which often isolates even invading growths. Some tumors are sharply limited. The removal of such a tumor could hardly fail to cause a traumatic inflammation that would damage and perhaps destroy all of the elements of the cord at the spot and would probably be permanent in its effects."

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[1] Read at the meeting of the New York Neurological Society, November 1, 1910.

[2] Text-book of Nervous Diseases, 1909, p. 442.

If it can be done with little or no injury to the cord, there is no valid reason why such localized growths should not be removed. We believe that some operators have in fact removed tumors from the substance of the cord, which appeared to them extramedullary. Schlesinger[4] declares that the tumors may bulge from the cord to such a degree that on first view they give the impression that they are extramedullary.

During the past year we have twice encountered what we believe to have been an intramedullary growth of the cord,[5] and in each case, by a method to be described, have removed the tumor from its bed in the cord substance.

CASE I.—*Intramedullary gliosarcoma of the cervical cord (fifth, sixth, and seventh segments); laminectomy and removal of the tumor in two stages; recovery.* Dr. B. L., aged forty-two years, was referred to the surgical department for operation from the service of Dr. J. Fraenkel on January 12, 1909, with the following history: After a sore throat in the spring of 1907, the patient began to suffer with pain in the back of the neck, of a boring character. The pain gradually spread over the shoulders and down the arms, and was followed by numbness in the right hand. For about two years these symptoms occurred in attacks, and between the attacks the patient felt well. In the summer of 1909 she first began to notice some awkwardness in the left arm, soon followed by considerable loss of power in the left arm, and later in the left leg. About this time the pains in the upper extremities grew less marked. By the fall of 1909 the awkwardness had affected also the right upper and lower extremities, and the patient's loss of power was so great that she had much difficulty in walking. Then followed a rapid loss of power in the upper extremities, especially the left, and a recurrence of the pain in the back of the neck and shoulders. Soon the lower limbs became weak and stiff.

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[3] Diseases of the Nervous System, 1899, p. 609.

[4] Handbuch der Path. Anatomie des Nervensystems, 1904, p. 1109 et seq.

[5] The first patient came from the service of Dr. Fraenkel, and the second from the service of Dr. Collins. We are indebted to these gentlemen for permission to use the histories and medical records.

General condition good; well nourished. Special senses normal; no difficulty in swallowing or in urination and defecation.

Pupils are of normal size, and react well to light and accommodation.

She has to be supported when she sits up in bed; she can walk only with the greatest difficulty when supported. The cervical and dorsal vertebral column are held rigid. There is marked tenderness on percussion over the spines of the fourth, fifth, and sixth cervical vertebræ. When the attempt is made to flex the neck on the chest, the patient has a feeling of constriction around the upper part of the chest.

The motor power in both upper extremities is much diminished, but much more on the left than on the right side. When the patient attempts to move either extremity there is coarse ataxia, and she says she does not know the position of the limbs unless she looks at them. The left arm can hardly be raised away from the body; all movements at the elbow are weak; extension of the forearm is impossible. All of the muscles of the left arm and forearm react only slightly to the faradic current; no contraction of the triceps can be obtained.

There is marked atrophy of the muscles forming the thenar and hypothenar eminences on the left side, of the triceps and the infraspinatus.

On the right side there are the same changes as on the left, but very much less marked.

The motor power in the lower extremities is much diminished, especially on the left side. The knee-jerks are exaggerated, especially on the left side; double ankle clonus, Babinski, Oppenheim, left greater than right.

The sensory changes are represented in Fig. 1.

X-ray examination failed to show any changes in the vertebral column. The fluid obtained by lumbar puncture was not under great pressure, and did not contain anything abnormal.

Surgical History. January 13, 1910, laminectomy, first stage (Dr. Elsberg). Median incision over spinous processes of fourth cervical to first dorsal vertebræ; exposure and removal of spines and laminæ in usual manner; little bleeding, well controlled by packings of hot saline solution. Dura tense; no pulsation can be seen or felt. Incision in dura, 5 cm. long; escape of moderate amount of cerebrospinal fluid from above; exposed portion of cord much enlarged; no evidence of tumor on any side of cord.

In incising the dura, the smooth posterior surface of the prominent and enlarged cord was nicked in two minute spots. From the small accidental openings distinct tumor tissue began to extrude from the otherwise intact cord. The minute openings were then united by an incision in the posterior surface of the cord, and the intramedullary growth became more and more prominent. It was evidently advisable to further enlarge the incision in the cord and allow the natural intramedullary pressure to gradually extrude the growth. The incision in the posterior column was then enlarged until it was 1 cm. long. Under the eye there then occurred extrusion of a small mass which was clearly tumor tissue, and which seemed to be connected with a larger mass within the substance of the cord.

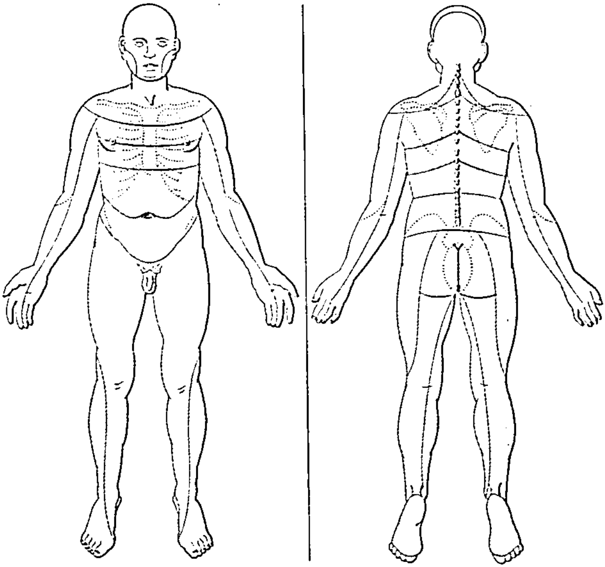

Fig. 1.—Case I. Verticals, hyperalgesia; horizontals, anesthesia; oblique lines, hypesthesia and hypalgesia.

The operation had thus far lasted only forty minutes, and little blood had been lost. The patient's condition was, however, not very good; she looked pale, and her pulse was 120, and only of fair quality. I concluded, therefore, to desist from any further manipulations for the time being. The muscles were carefully sutured, together with interrupted catgut stitches, the fascia with a continuous stitch, and the skin edges united by a subcuticular suture. Voluminous dry dressing.

The patient was in good condition on the following day, but the second operation was delayed for one week.

January 20. Ether anesthesia; dressings removed; wound had healed by primary union; wound reopened and dura and cord exposed (Dr. Elsberg).

A large tumor mass had been extruded from the cord and lay almost outside of and on top of the cord between the fourth cervical and first dorsal segments. With little difficulty, very slight handling of cord substance, and practically no bleeding, the tumor was peeled out of its bed. Three posterior nerve roots on the left side ended in a thin layer of cord tissues, which formed part of the wall of the cavity left after removal of the tumor.

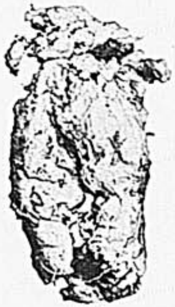

Fig. 2.—Intramedullary tumor of cervical cord removed from Dr. L. in two stages.

After careful cleansing of the cavity the edges of the pia were sutured together with fine catgut; the dura closed by a running suture of fine silk, and the muscles and skin united by catgut sutures. Dry dressing. Duration of operation, fifty-five minutes; condition of patient at end of operation good; pulse 108, and of good quality; respirations regular and deep.

The tumor that had been removed was of a reddish-brown color; soft and edematous; it measured 5.3 by 2 cm., weighed 15 grams. The specimen (Fig. 2) was examined by Dr. F. S. Mandlebaum, director of the laboratory of the Mt. Sinai Hospital, who reported it to be a gliosarcoma.

The patient made a rapid recovery from the operation. The wound healed by primary union, and all dressings were discarded after the second week.

For the first few days after the operation the weakness in the extremities and the sensory disturbances were somewhat more marked. Rapid improvement followed. By the end of the fourth week the patient was able to sit up out of bed, without assistance. The muscular power in the limbs improved rapidly; by the time she sat up out of bed, she had regained practically all of her power in the right and very much power in the left upper limb. The paralysis of the triceps had disappeared. The muscular power in the lower extremities returned somewhat more slowly, but there was a constant and steady improvement.

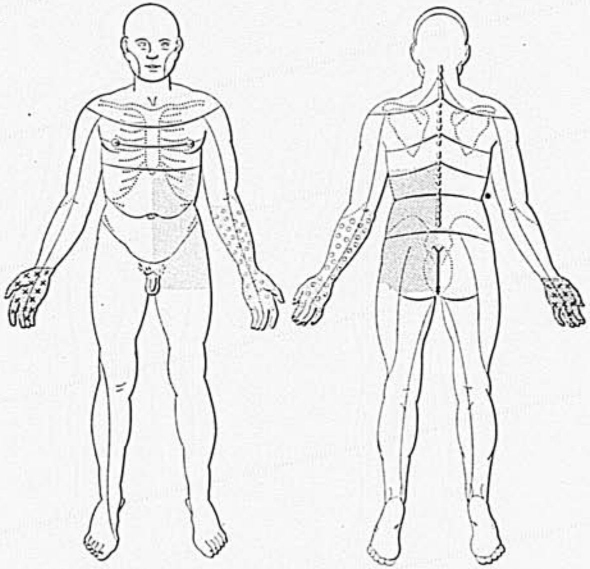

Fig. 3.—Case I. Sensory disturbances eight weeks after the removal of the tumor; areas shaded similar to those in Fig. 1. Crosses, hyperalgesia to hot and cold; circles, analgesia to heat and cold.

By the beginning of March (two months after the operation) she was able to stand on her feet and take a few steps when well supported; but her lower limbs, especially the left, were still very ataxic. Most of her sensory disturbances had by this time disappeared (Fig. 3).

At the present time, eight months after the operation, she can write and use the typewriter, and can walk considerable distances without support. She still has some hyperesthesia in the left hand, and her lower limbs, especially the left, are still somewhat stiff. She is steadily improving. This improvement has been much aided by thorough massage and exercises, which have been given her by Dr. Wolf of this city.

REMARKS. This case is of unusual interest. The patient was transferred to the surgical department by Dr. Fraenkel, with the diagnosis of tumor of the cord between the fourth and seventh cervical segments.

At the second operation we were not absolutely certain that the tumor was a true intramedullary one, and considered that possibly, in spite of the fact that underneath the pia part of the lining wall of the tumor was formed by tissue containing the superficial origin of several nerve roots, and that we had incised the cord substance in order to allow the tumor to extrude, the tumor had simply been one underneath the pia which had grown into the cord in such a way that the cord bulged around the tumor. A more careful study combined with the experience that we had in a similar case which came to autopsy, and in which a careful examination of the cavity of the cord was made for us, has convinced us that both were cases of intramedullary growths of the cord. At the first operation the small accidental incisions into the cord and the subsequent more liberal incision on the posterior aspect of the cord proper exposed the intramedullary tumor. At the second operation the large extruded growth had been squeezed out of its intramedullary bed, and could be lifted up and peeled off with ease, leaving the wall of the cavity in the cord. On the left side, three posterior nerve roots could be seen running into the thin shell of the cord, which at this point had enveloped the neoplasm.

CASE II.—*Intramedullary tumor (glioma) of the cervical cord (fourth to sixth segments); laminectomy and removal; death in four hours from respiratory paralysis.* Sarah B., aged forty years, was referred to the surgical department with the diagnosis of tumor of the cervical cord, from the service of Dr. Joseph Collins, on February 18, 1910.

About two years before, the patient began to have pain in both upper extremities, and at the same time noticed that her arms were becoming weak. The left arm was affected more than the right, but the symptoms began at the same time in both limbs. The limbs gradually became weaker, and about one year later she began to have attacks of pain in her abdomen.

For the last six months the patient has been unable to walk or to use her lower limbs, and for two months she has not had control of her urine.

The patient was in poor condition when admitted into the service of Dr. Collins, so that it was impossible to obtain much history from her. She frequently contradicted herself.

She was much emaciated; her pulse was very weak; she was constantly wet from incontinence of urine.

Marked tenderness to percussion over the third, fourth, and fifth cervical spines. Decided atrophy of interossei on both sides of upper extremities; marked flattening of thenar and hypothenar eminences. Arms do not seem atrophied. Flexion of forearms on arms is good; extension is decidedly weak; there is only a weak contraction of the triceps muscle; all movements of arms and forearms are weak; reflexes at elbows and wrist-jerks cannot be obtained.

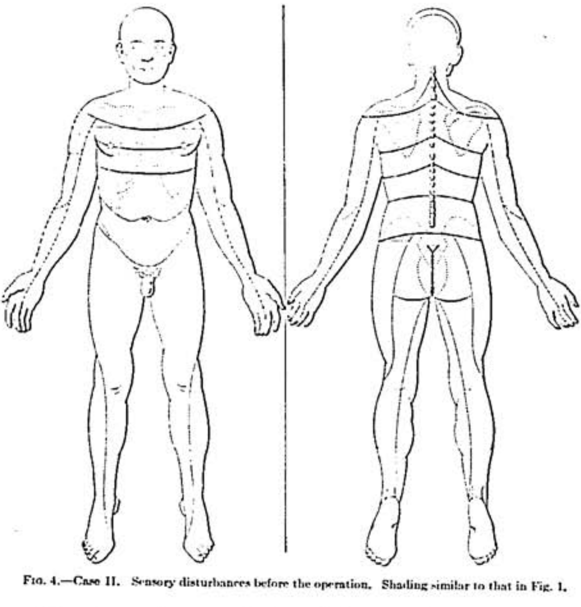

FIG. 4.—Case II. Sensory disturbances before the operation. Shading similar to that in Fig. 1.

There is complete paraplegia, with increased knee-jerks, ankle clonus, Babinski, Oppenheim, and Mendel-Bechterew.

For sensory changes see Fig. 4.

There is marked tenderness to pressure over the spinous processes of the third, fourth, and fifth cervical vertebræ, especially over the fourth.

February 19. Patient has been rapidly growing weaker. She is frequently cyanosed, and has difficulty in breathing. At times her pulse is almost imperceptible.

February 19. Laminectomy (Dr. Elsberg). Removal of fourth, fifth, sixth, and seventh cervical and first dorsal spines and laminæ in the usual manner. In the upper part of the exposed dura the pulsation was marked; below no pulsation could be observed. Incision of the dura for 5 cm.; cord appears much distended between fourth and sixth segments; palpation of cord substance reveals in this region a marked tumefaction of this part of the cord. Above the affected area the cord looks soft and pulsates markedly, while the part of the cord in which the tumor lies does not pulsate. A small incision was now made in the pia over the most prominent part of the cord in the median line; at once a part of a tumor mass bulged through the cord tissue. The incision was then lengthened and deepened, when the tumor at once began to bulge out of the cord substance. The intramedullary pressure seemed so great that in a few minutes the larger part of the growth was extruded. As it was well encapsulated, it was lifted out of its bed with ease, and with practically no bleeding. After the wound in the cord had been thoroughly irrigated with saline solution, the cavity in the cord with the overlying pia was closed by interrupted sutures of fine silk, and the dura and soft tissues closed in the usual manner.

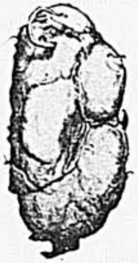

Fig. 5.—Intramedullary tumor of cervical cord removed from the patient, Mrs. B.

The tumor (Fig. 5) measured 4½ by 2 cm.; it was of a yellow color, and fairly hard. The microscopic examination revealed it to be a cystic glioma.

The entire operation had lasted less than forty minutes. At the conclusion, the patient looked slightly cyanosed, although the respirations were regular and deep. The pulse was weak, and varied between 112 and 120. The character of the pulse was no worse than it had been at the beginning, and the patient did not look at all shocked. Three-quarters of an hour later she was fully awake, and asked for water; she was still slightly cyanosed, and her breathing had a jerky character. Two and one-half hours later she suddenly became pale, her pupils widely dilated, and no pulse could be felt at the wrist. A few minutes later the breathing stopped. In spite of active stimulation, artificial respiration, intratracheal insufflation of oxygen, her heart action became rapidly poorer until death occurred.

At the postmortem examination the wound was found in perfect condition; there were no clots in the cavity in the cord (Fig. 6).[6]

Remarks. This patient grew worse so rapidly that operative interference, if done at all, had to be done without delay. The removal of the tumor, after its exposure, occupied two or three

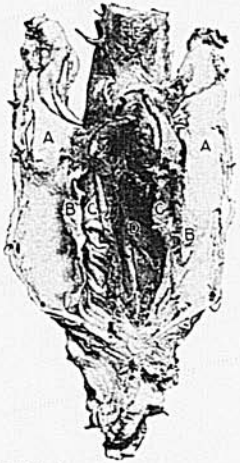

Fig. 6.—Part of cervical cord of Mrs. B.: *A*, dura; *B*, pia; *C*, cord tissue with origins of posterior nerve roots; *D*, cavity in substance of cord left after removal of tumor; *E*, cord.

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[6] We are indebted to Dr. I. Strauss, of the Cornell University Medical School, for the examination and following report on the tumor and cord:

"The tumor is a very cellular glioma. The piece of growth examined has a thin capsule, which contains bloodvessels and stains red with Van Gieson stain.

"The section of the spinal cord shows an absence of the posterior columns, which is due to the presence of the growth in this region. The posterior horns of the gray matter are present, and the posterior roots and their entrance zones are preserved. The bases of both posterior horns are abnormally vascular, probably because of the attachment of the tumor. The anterior wall of the central canal can be recognized from the presence of a few epithelial cells, which lie dorsally to what remains of the anterior commissure. The posterior wall has been destroyed by the growth or through its removal. The anterior horns and their ganglion cells are fairly well preserved. The anterior spinal vessels, both artery and vein, are unusually large and tortuous, and suggest that they may have been concerned in furnishing the blood supply to the tumor."

minutes, and we therefore felt that it was justifiable to do the entire operation in one stage. The dura was fully exposed within ten minutes after the incision of the skin, and the tumor was out within twenty-two minutes of the first incision.

It is very possible, however, that the unfortunate outcome might have been prevented if the operation had been done in two stages. The extrusion of the tumor occurred under the eye, and it would have been better to have allowed the cord structures to have accommodated themselves to their new relations before the actual removal of the tumor.

The above two operations for intramedullary tumors of the cord demonstrate that localized growths of the cord substance must not be considered as inoperable. They should be attacked by the neurological surgeon as readily as subcortical tumors of the brain. The results should be at least as good as those obtained in subcortical intracranial growths. A small incision in the lumbar cord near the posterior median fissure will injure only sensory fibers from the posterior roots of some sacral nerve fibers which regularly degenerate upward when the lower lumbar and sacral posterior nerve roots are divided. These sacral fibers at first occupy a position near the posterior median fissure of the cord, and in their upward course gradually come to lie nearer and nearer to the posterior surface of the posterior median column. The lumbar, dorsal, and cervical ascending fibers lie in order farther and farther forward, and are not apt to be injured when a superficial incision in the posterior column near the median line is made. The main bundles of descending fibers in the posterior columns lie in situations where they are not apt to be injured.

From the above description of the course of fibers as given by Van Gehuchten, it follows that a small incision in the posterior median column will injure or divide fine ascending fibers which are derived from the posterior root fibers of the sacral, lumbar, and perhaps lower thoracic nerves. After having travelled a short distance in the posterolateral white column (column of Burdach), they run up the posteromedian column (column of Goll) into the medulla oblongata.

Based on the anatomical grounds above stated, the writers suggest the following method of treatment for intramedullary tumors of the cord. If after laminectomy and incision of the dura the surgeon finds that he has to deal with a localized intramedullary growth, he should make a small incision, about 1 cm. long, in the posterior median column a few millimeters outside of the posterior median fissure, at the spot where the growth seems to be nearest the surface of the cord. The incision should be deep enough to cut the pia and the substance of the column down to the tumor. The tumor will then begin to bulge through the incision. No matter how markedly the tumor will seem to bulge, the surgeon must not attempt to remove the growth, for he will be sure to cause grave injury to the cord. He must leave it to nature to extrude the tumor. As the normal intramedullary pressure will tend to readjust itself, the growth, which has caused an increased pressure, will be gradually pushed out of its bed. Nature will do this by a slow and gradual process, and the tumor will be slowly extruded, with a minimum of injury of nerve fibers. Therefore, after the small incision into the cord has been made, the muscles and skin must be closed and the actual removal of the growth left to a second operation.[7] After about one week the wound is reopened and the tumor, which will in all probability be found outside of the cord, can be removed by dividing the few adhesions which remain. If the manipulations are done with delicacy and care, no injury should be done to the cord substance. When the tumor has been removed, the pia should be closed by fine silk sutures, and the dura, muscles, and skin sutured in the usual manner.

In the case of intramedullary tumors which extend over a large number of segments, and which infiltrate the cord substance, a small incision into the cord made in the manner above described at the level of the most marked symptoms, may allow of the partial extrusion of the tumor, with perhaps amelioration of the symptoms.

It is not at all beyond the range of possibility that some cases of spinal gliosis, syringomyelia, and hematomyelia will come into the domain of the surgeon. It is perfectly feasible to drain a central cavity in the cord into the subdural space, and perhaps prevent the symptoms due to pressure of the fluid upon the nerve fibers. In the same way it may be possible to benefit certain cases of hematomyelia by allowing the blood clot to be extruded from the substance of the cord.[8]

The method of treatment above described we have called the "extrusion of intramedullary tumors." We believe that the application of the principle of extrusion to the surgery of intramedullary growths of the cord will open up a new field to neurological surgery. The cases which are reported in this paper are presented as evidence in favor of this view.[9]

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[7] In a recent paper (The Special Field of Neurological Surgery, Five Years Later, Bulletin of the Johns Hopkins Hospital, November, 1910) Cushing gives a short description of a case of glioma in the substance of the cord, in which he made an incision in the posterior column and removed a specimen for examination. The improvement in the patient's symptoms was so marked that, Cushing states, "she has so far recovered as to make us regret that the posterior column was not slit throughout the whole length of the exposed and tense cord." Perhaps the improvement was due to the gradual extrusion of the tumor.

[8] In the case of a recent patient from the service of Dr. Bailey, who was operated upon by Dr. Beer, an extensive intramedullary clot was found in the dorsal cord. The intramedullary clot was treated by the method of extrusion. Much old blood was extruded from the cavity in the cord. The condition was probably one of hemorrhage into a cystic glioma or into a cavity of syringomyelia. The patient has fully recovered from the operation, and there has been considerable improvement, but it is too early to say how great the improvement will be.

[9] In a paper published in October, 1909, Zeaner and Kramer made a similar suggestion regarding the possibility of the delivery of brain tumors "by the pressure from behind."